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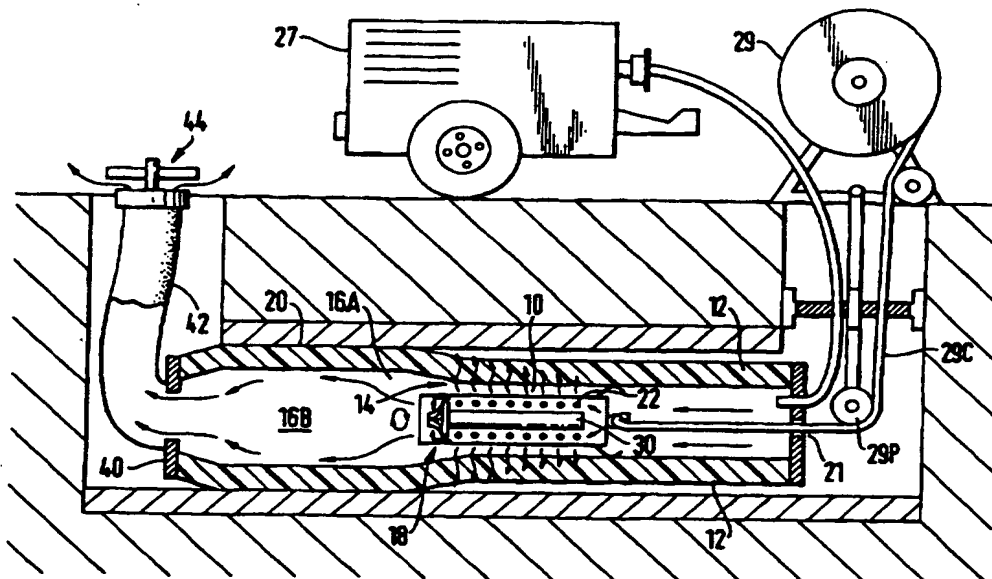
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(54) Title: RE-FORMING THERMOPLASTIC MEMBERS



## (57) Abstract

Method and apparatus for re-forming walled thermoplastics members including pipe (12) as re-lining of worn-out pipeline (20) by heating (14) to soften throughout wall thickness without melting, and re-sizing/re-shaping by fluid pressure (16). Infrared heating radiation (14) and progressive change of thermoplastics (polyethylene) from absorptive to useful transparency at or near crystalline melt (below full melt) temperature allows self-regulation of heating, as well as replacement of original thermoplastic memory of geometry. Preferred compact machine (10) combines heating elements array (22), pressurising gas turbine (18) and electric power generator (30) in coaxial/concentric arrangement.

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TITLE: RE-FORMING THERMOPLASTIC MEMBERS  
Technical Field

The invention relates to re-forming thermoplastics members, including method and apparatus for re-sizing and  
5 re-shaping re-lining pipes for damaged or worn-out underground pipelines to avoid the need for excavation.

Such pipelines typically carry gas or water under head or pressure, or sewage services, in urban areas. Some existing pipe lines are over 100 years old and are in a sad  
10 state of disrepair due to various factors including damage due to ground movement, corrosion and crumbling.

Technical Background

The idea of "no-dig" repairs of pipelines is not new. For more than 25 years, the so-called "Insituform" (RTM)  
15 process has been used to re-line sewer pipelines. This process was the first of what are now called soft-lining methods of pipeline rehabilitation. A long tube of woven felt serves as the lining material and is impregnated with epoxy or polyester resin. This tube is installed in the  
20 host pipeline using an inversion process and is then cured in situ to form a structural repair.

Slip-lining is a simple alternative method for thermoplastic re-lining. An undersized, extruded thermoplastics pipe is dragged through the original pipeline and gaps left  
25 between the undersized pipe and the host pipeline are filled using a grout, at least to stop sewage etc intendedly entrant from lateral connections from flowing into/through such gaps. Even for repairs without lateral connections, grouting is often needed to stabilise the  
30 under-size slip-lining in position. Whether or not limited to positions of lateral connections, excavation is required at intervals for grouting, necessitating host pipeline run location being accurately determined from often old site-plans.

35 Swage-down systems can assist meeting annular gap problems of slip-lining, by taking a full-size re-lining thermoplastics pipe and squashing, or swaging, it undersize

using hydraulic rams to fit it into the host pipeline. High pressure air is used to re-expand the new pipe when it is in position, and thermoplastic memory from the pipe extrusion process as to full-size geometry assists system stability over time. Gaps are, however, not fully eliminated by this system since the match between the diameters of the old pipeline and the pre-swaged plastic pipe will only rarely be perfect. Often, within the any length of re-lined host pipeline, some sections of re-lining pipe will be loose, and some parts the plastic pipe need to take on a distorted shape in order to fit. Swage-down systems cannot produce a 'dimple' for use by robot hole-cutters, which means that each lateral connection position usually has to be excavated to re-connect it.

15 So-called U-liner systems are alternative to swage-down with two main differences. The re-lining thermoplastic pipe is extruded round then folded into a "U" shape in cross-section at the pipe manufacturing plant, so as to facilitate fitting inside a host pipeline. The temperature at which the pipe is formed into the U shape is critical because of the way that temperature affects the pipe's thermoplastic memory. Also, steam is blown through the central channel of the folded re-lining pipe to soften it sufficiently for it to be inserted through a standard man-hole access to the host pipeline. Once dragged into place, the re-lining pipe is inflated against the host pipeline using air pressure. It has been claimed that the steaming will induce a new thermoplastic memory for the pipe at this stage. However, the close-fit tends to be short-lived, which is not surprising as simple steaming is limited to 100°C, thus below typical crystalline melt temperatures, e.g. 120°C for polyethylene, to be exceeded for erasing/replacement of thermoplastic memory. Thus, there is a tendency for the pipe to revert or creep back over time to the extruded diameter, which means results are no better than for Swage-down. At worst, the pipe can seek to revert to the U shape because of imperfect temperature control

during forming of the "U" shape off the extrusion line.

Another problem with U-bending arises from dragging the folded re-lining pipe into position while very soft. The Youngs modulus of polyethylene at 100°C is low and the pipe stretches easily, even with just friction to overcome in dragging into position. Because no new thermoplastic memory is set, residual stress can appear in the re-lining pipe as it cools and tries to revert to its original geometry, including as to length. This can cause longitudinal creep movement, including as to intended positions of any lateral holes that have been cut in the pipe.

It is one particular object of this invention to mitigate such problem(s), though other applications arise.

#### Disclosure of Invention

According to one particular aspect of this invention, there is provided a method of re-sizing or re-shaping a hollow thermo-plastics member, conveniently elongate, say tubular, comprising the steps of heating the thermoplastics material of the member to soften it, and applying fluid pressure, conveniently pressurised gas, to alter its size and/or shape, wherein the heating is by electromagnetic radiation to which the thermoplastics material both develops a degree of transparency without melting that at least reduces further heating up and softens enough to be re-sized and/or re-shaped as desired by said fluid pressure application. Advantageously, re-forming is at or above a temperature at which thermoplastic memory as to original geometry becomes at least partially erased and usefully replaced by the re-formed geometry.

According to another particular aspect of this invention, there is provided apparatus for re-sizing or re-shaping a hollow or thermoplastics member, conveniently elongate, say tubular, comprising means for heating the thermoplastics material of the member to soften it, and means for applying fluid pressure, conveniently pressurised gas, to alter the size and/or shape of the hollow member after its thermo-plastic material is softened by said

heating, wherein the means for heating serves to provide electromagnetic radiation to which said thermoplastics material is absorptive before developing a degree of transparency without melting that at least reduces further heating up and is then soft enough to be re-sized and/or re-shaped as desired by said fluid pressure, preferably at or above a temperature at which thermoplastic memory as to original geometry becomes at least partially erased and replaced.

Conceptually, including as to the original motivating context of improving lining/re-lining pipes, particularly underground pipelines, or other conduits, this invention can be seen as seeking to modify known production processes blowing gas into soft, often near-molten, material to stretch and expand that material into a desired actual product. Such processes are widely used, with or without external product-related form-imposing constraint or moulds, for producing such things as plastics film whether to be substantially form-sustaining or to be stretchable, inflatable elastomeric balloons, various hollow-ware often of necked bottle or flask type, etc. In themselves, of course, such production processes can be seen as derivative from, indeed include, age-old forming of hollow glassware. Initially, apparent absence of proposed application of such processes to re-forming, i.e. going from an initial already-made product form to a modified product form, with particular reference to thermoplastics products, seemed surprising.

However, profound difficulties quickly came to light, particularly for polyethylene or other typical or feasible thermoplastics re-lining pipe material. Thus, melt temperatures and other thermal properties of such materials, particularly low heat conductivity and high specific heat (leading to very steep temperature gradients in normal wall thicknesses, typically 25mm and more, of re-lining pipe, that deleterious surface melting occurs before the whole is soft enough to expand satisfactorily, particularly when

heating from one side only as is only practical from the interior of a re-lining pipe. These problems are drastically exacerbated by the further highly desirable objective of achieving softness throughout wall thickness that effectively erases as-produced pre-reformed thermo-  
5 plastic memory and replaces it by post-reformed thermo-plastic memory. Crystallinity inevitable at envisaged wall thicknesses, and complexity of pre-full-melt phases of thermoplastics materials, contribute.

10 General method and apparatus aspects of this invention arise from solving these problems/difficulties, basically by adaptation of conventional thermoplastics materials for re-lining pipes, or other hollow or walled members that inherently present similar problems for any desired re-  
15 forming, so that heating means utilised achieves a sufficiently uniform softening of the thermoplastics material throughout its wall thickness for desired re-forming by applied fluid pressure, further preferably (as above) achieving softness (believed to correspond to what  
20 is known as crystalline melt occurring before going fully molten) sufficient for at least partial erasure/replacement of thermoplastic memory for subsequent re-formed product stability.

It will be appreciated that, as well as expansion as  
25 envisaged for re-lining pipes, contraction down, say onto a former, could be done where there is exterior access to the thermoplastics member to be re-formed.

Thermoplastics material adaptations can involve inclusions of other materials, for example conductive if  
30 contact heating is to be used, say by super-heated steam; or electrical reactance responsive if electrical induction heating is to be used; or other relevantly suitable suitably energy-absorptive, say for microwave heating. Such inclusions could be of particulate or filamentary  
35 type, or be as sheets, such as of mesh or other expanded forms, say corrugated longitudinally if not otherwise expansible with desired re-forming of the thermoplastics

material itself.

The aforementioned effective transparency together with re-formability, preferably with geometric memory replacement, i.e. at or close to crystalline melt or above  
5 up to full melt temperatures of thermoplastic materials, has great advantages by way of capability for self-regulation in relation to effects, including scattering, of applied electro-magnetic heating radiation capable of required heat intensity. Inclusions in the thermoplastics  
10 material may also assist in relation to internal heat retention and/or transparency/opaqueness adjustment, e.g. fine particles (typically 45 nanometres nominal) of carbon black in small quantities (typically 100 - 1000 ppm).

For typical polyethylene re-lining pipe materials, and  
15 heating radiation in infra-red extending into visible light spectrum, it was found that the desired effective transparency effect does not occur in its common or normal black, yellow and blue pigmentations, but does happen for so-called "natural" polythene, as readily available with a  
20 creamy white hue. Other infra-red transparent colouration of at least surfaces could, of course, be used.

For conductive, inductive or microwave assisting inclusions in appropriate content/form for suitably even or satisfactorily low temperature gradient through wall thick-  
25 ness of the member concerned, and satisfactorily high heat intensity achieved (say comparable with that for infra-red/visible light), temperature sensing and heating control means will ordinarily be required. However, for electro-magnetic radiation heating accompanied by transition to  
30 effective transparency, there will be a simple and automatic progressive softening from incident to opposite surface, with little or no further in-material heating at such transparency. This is particularly attractive for a re-lining pipe re-forming machine that may simply be towed  
35 at a rate known to be effective, preferably with compressed gas applied immediately, conveniently from a turbine associated with the heating means, further preferably



serving for any necessary or desired cooling, whether of expanded re-lining pipe or of the heating means itself.

Any suitable compressed gas may be used, e.g. air or inert (such as carbon dioxide) for safety against explosion risks; and, at least for re-lining a host pipeline, means can be provided for creating back pressure in the re-lining pipe downstream of the preferably movable heater to cause the softened pipe to re-size. Suitable apparatus could include means for creating a pressure chamber sealed against the surface of the member, means for pressurizing the chamber and means for detecting a pressure drop in the chamber indicative, for example, of a rupture in the member. The pressurizing means may apply pressure pulses to such chamber or against other suitable back-pressure.

#### 15 Brief Description of Drawings

Specific implementation for this invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:-

Figure 1 is an overall longitudinal sectional view of one apparatus;

Figure 2 is a longitudinal sectional view of heating means;

Figure 3 is an overall longitudinal sectional view of another apparatus;

Figure 4 is a schematic view of a device for detecting bursts in the wall of re-lining pipe;

Figure 5 is a diagram showing heating re-lining pipe wall locally in restoring a lateral connection; and

Figure 6 shows a further stage in restoring a lateral connection, after the heating stage of Figure 5.

#### 30 Modes of Carrying Out Invention

In Figures 1 and 2, heating machine 10 is pulled through undersized thermoplastics re-lining pipe 12 to soften it by its absorption of at least infra-red radiation 14. Fluid pressure, specifically compressed gas 16, is used to expand the softened re-lining pipe 12 at 16A into contact with host pipeline 20 to exclude annular gaps,

ideally give general closely intimate fit. The fluid flow 16 is also shown at 16B cooling the expanded re-lining pipe 12. The process can be continuous, with the heater 12 shown integrated with gas flow turbine 18.

5           Evacuated Halogen lamps or Ni-Chrome wire can serve as heating elements 22 and source of radiant infra-red heat, typically accompanied by visible light to which preferred thermo-plastics materials also become transparent. Chromed or polished aluminium reflector(s) 24 usefully serve to  
10 direct the radiation from the heating elements 22, with forced cooling at 16C on its way to turbine drive nozzle 18N, to ensure that the heaters 22 and the reflectors 24 do not overheat within preferred transparent glass containing tube 23.

15           Electricity for driving preferred elongate, advantageously annular, arrays of heating lamps/elements 22 could be taken directly from electrical cables put into the pipe, but, as preferred on safety and logistical grounds, use is shown of a further integration into the heating machine  
20 of a generator 30 shown having, inside and concentric with the array 22, windings 32 and rotating magnet assembly 34 in bearings 36, and also sharing cooling by incoming gas supply.

          Input cold gas flow 16C to the turbo-generator 18/30  
25 is shown coming through re-lining pipe end sealing gland 21 from an above-ground compressor 27 through an upstream manhole also accommodating haulage cable 29C from winch 29 through stabilising pulley provisions 29P and the gland 21. The gas, conveniently air, goes past elastomeric wiping  
30 seal 26 to the re-lining pipe 12 and is shown channelled at 27 to flow over the lamps/elements 22 and reflector(s) 24 to keep them cool in the glass tube 23. Cooling air-speeds of up to 100 meters/second can be used without incurring too much turbulent energy loss. Not all of the heat  
35 removed by cooling the lamps/elements 22 and reflector(s) 24 is wasted because it effectively gets transferred to the input gas to the turbine 18, thus raising the temperature

and therefore the gas pressure. Much of the removed heat energy is therefore recovered due to the increased work that can be extracted by the turbine wheel from the hotter, higher pressure gas. High pressure gas goes from end 40 of the re-lining pipe 12 through flexible conduit 42 to a back-pressure regulating valve 44 shown at a downstream manhole, and serving to assure desired expansion/cooling. Alternatively, back-pressuring means might be towed along behind the machine 10.

Towing the pressure regulator behind the re-sizing machine means that only one lateral hole need be coped with at any one time. Also, it means that the holes will not become pressurised, since air is free to escape. This allows the possibility of putting an inflation sock bag, say of PTFE, to seal the laterals, at least behind though feasibly wholly over the entire machine.

Rather than atmospheric air as the pressurised and cooling gas, for which the embodiment of Figures 1 and 2 is particularly designed, some other and safer gas could be used, usually inert, for example carbon dioxide, see Figure 3. The same references are used advanced by one hundred for the same or functionally similar items. Differences mainly concern external gas supply bottle 150, above-ground turbo-compressor 152 for its pressurising to high re-lining pipe 112 expanding pressure, high and low pressure flexible gas flow lines 154 and 156 to and from seals to heating machine 110 for internal cooling flow therethrough, and intercooler 158 for low pressure gas return to the turbo-compressor 152. Haulage line 129P to winch 129 is shown passing through a high pressure seal in gas flow line 154, but any practical arrangement is feasible, including remotely controlled self-propulsion for the heater machine 110.

Combination heater/generator or heater/turbine or heater/generator/turbine machines for traversing pipes etc constitute another aspect of this invention by way of such combination(s) together, preferably with plural heating

elements, conveniently in an annular preferably elongate array; and further preferably with trailing end turbine and/or inner reflector means and/or electric generator provision, conveniently either or both concentric with  
5 heating element array; and/or suitably transparent containment of heating element(s) etc and/or defining a heating element(s) and reflector(s) cooling path for turbine gas supply; and/or (see below) control means for unwanted radiation components from the heater by suppression and/or  
10 filtering.

Preferred embodiments of such machine, e.g. as at 10/18 etc (or 110/118) can be advantageously compact, particularly that can be winched through a 7-inch (ca. 175mm) re-lining pipe, including being no more than about  
15 18" (ca. 450mm) long in order to negotiate normal bends. Moreover, thermal characteristics, including high latent heat, of most thermoplastics, perhaps particularly polyethylene, lead to a joule-heat requirement for standard re-lining pipes of at least 25 kW of power to re-form a  
20 100m length of pipe in one hour, which can be met by compact machines hereof capable of (non-limiting) projected practical minimum process speed to suit. Turbo-generator requirements need be only four-pole, as frequency of operation is relatively unimportant for a generator so long  
25 as the load can be altered to suit the voltage that it outputs. A 40kW, 40,000 RPM brushless motor could be driven in reverse by a turbine wheel to produce the required power.

With thermoplastics, typically polyethylene, re-lining  
30 pipe material soft, see Figure 4, the expansion pressure will stretch the material into any unsupported void, particularly of a lateral connection 60, at least to form a "dimple" 62, if not a burst 64 (dimple formation omitted) if inflation pressure is high enough and/or the material  
35 soft enough. An unburst dimple 62 facilitates finding lateral connections 60 for later cutting, conveniently by a conventional cutter robot. A blow-out hole 62 may self-

heal to some extent, because, as soon as a hole forms, gas will rush out of it, cooling the thermoplastics material down and consolidating it. Loss of gas flow through small holes may not be significant, even in lateral connections, at the expansion pressure(s) envisaged. Compared to the very high flow through downstream back-pressure regulation valve 44, loss of air into laterals may not significantly affect the inflation pressure regulation.

If effects of burst-outs are not desired and cannot be prevented any other way, a pre-liner could be used. A thin sock of high strength, transparent, higher melt temperature plastic (e.g. polypropylene) could be gas-inverted into the host pipeline prior to re-lining.

Detecting positions of burst-outs might be simply by monitoring gas pressure changes at the back-pressure valve 44. Alternatively, a simple pressurised gas machine could be dragged through the re-formed re-lining pipe (or 112) with end sealing provisions 68A,B and pressure loss detection signalled over line 69. However, incidence of re-lining pipe blow-outs is turned to advantage herein at lateral connections, see Figures 5 and 6. A machine 70 (which could include position detection of Figure 4) dragged through the re-formed re-lining pipe (or 112), is also shown with end sealing provisions 72A,B to define a chamber 74 which can be pressurized. Reduction in pressure in the chamber 74 again indicates the presence of a blow-hole as an increase in gas-flow above the normal leakage rate of the seal provisions 72A,B. Pulses of air could be used to avoid pressurising lateral connection associated with the blow-hole 78.

Reinstating good lateral connection at 78 involves heating to softening the thermoplastics material locally, much as was done at installation. An infra-red heat source 80 and directional reflector 84 on a rotatable carrier 86 serves to soften the area around the blow-hole 78/lateral

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connection 76, this time typically using an external electric source if allowed by the low power requirement. Then, the carrier 86 is rotated a half turn and a balloon 88 is inflated to push softened thermoplastics material 5 into the lateral connection 76. This machine 70 could be towed along behind the basic expansion machines 10 and 110 of Figures 1 to 3, and serve in desired back-pressuring.

Reverting to basic desired softening etc action, heating in the thermoplastics of the pipe 12 (or 112) 10 should not be uneven and thus lead to local melting and cold spots. Using infra-red, heat absorption is virtually only in whatever is its instant penetration depth, and falling exponentially through it. The penetration depth is low for opaque polyethylene due to intrinsic low thermal 15 conductivity and high specific heat, which would cause surface melting, with remaining thickness staying cold. For a fully transparent material, there would, of course, be virtually no heat absorption at all. For an idealised material otherwise with the thermal characteristics of 20 polyethylene, but a particular degree of transparency such that all incident infra-red radiation was captured in the thickness of the wall of the pipe 12 (or 112), the temperature gradient through that thickness would be very steep, and the material could not soften towards the outer 25 surface before the inner surface melted. Intermediate degrees of transparency might take off enough energy as heat on all incident radiation eventually to heat up to desired temperature, but efficiency would be very low

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(leading to excessive heating of the host pipe) without good reflection provisions for multiple wall thickness traversals by the radiation (adding greatly to complexity and processing time).

5        So-called "natural" creamy-white polyethylene (due to crystallinity though free of normal pigments) discloses the property of going from opaque enough for absorption, including internal scattering effects, typically up to about 70% of incident infra-red radiation, to heat up to  
10 the desired temperature at which it goes transparent enough (or perhaps change of refractive index is involved, the exact mechanism not being fully understood at this stage, see below regarding optical transparency having been noted) to limit further heating below full melting; and to do so  
15 progressively through the thickness from incident to other surface, see idealised in sloping line 28.

Further refinement can include taking steps to reduce radiation content at certain frequencies/wave-lengths related C-H resonance to which particular thermoplastics  
20 materials are or may be particularly susceptible, including as to surface burning, e.g. fundamentals peaking at 0.9, 1.2 and 1.74 micrometre and odd (or coincident, e.g. 3.5 micrometre) harmonics for polyethylene. This is readily done in various ways using generally known filter and/or  
25 suppression techniques readily tailored specifically to the purposes hereof. For example, suitable dielectric material can be installed on the glass tube 23, often a combination of materials and layers, say at 23A on its inner surface

where reflection is involved in discrimination and unwanted radiation components eventually dissipate between the filter and the reflector 24. Alternatively the heating elements may be coated with frequency selective suppressive materials, such as various oxides on Ni-Chrome heating elements. Perhaps even more simply, an appropriate sample of the thermoplastics material concerned could be used on a sacrificial basis as a filter.

As a non-limiting postulation of self-regulating action in such as polyethylene, noted sudden increase in optical transparency appears accompanied by pronounced softening, at a particular temperature close to and through crystalline melt, perhaps attributable to random re-orientation of its long polymer molecule chains and associated loss of geometric memory, ultimately in favour of the new shape. In any event, in practice, procedures hereof will even allow for re-sizing machine becoming stuck in one position, i.e. without melting the re-lining pipe even if infra-red radiation continues (then merely going into the host pipe structure, often cast iron so harmlessly heat conducting), though it would obviously make best sense to stop heating temporarily if release of the machine is going to be long delayed.

Although infra-red is a preferred energy source, any frequency, or spectrum of frequencies which are absorbed by and heats the thermoplastic will work. White-light halogen lamps are certainly feasible sources of power. They are understood to output about 40% of their energy in the



visible spectrum, the rest being infra-red. Having at least some output energy in the visible spectrum has one advantage in allowing ready optical monitoring of progress. Also, optical clarity of the material when it softens may  
5 be better in the visible region than in the infra-red. So, at least significant (if not all should that be desired) visible spectrum heating could mean that, once softened, the heat take-up rate would be so low as to give indefinite time for the machine to be stopped in one place with the  
10 lamps running, but without melting the plastic. A possible disadvantage in using predominantly white light could be reflectivity of whitish cold polyethylene slowing heating up, and requiring plural traversals over the lamps between the pipe and the reflector(s) in being absorbed in the  
15 polyethylene. This increases the heat loss in the reflector and may also mean that the lamps run hotter.

Lamp output frequencies could be tailored to some extent to suit any preferential colour absorption pattern of the particular plastics material to be heated. Heat  
20 intensity from such as Ni-Chrome wires can be adjusted by controlling the current density, and therefore heat intensity in the wires, though Ni-Chrome wires should not be run white hot because they would either oxidise or melt at these temperatures. For white light, tungsten elements  
25 in an inert atmosphere could be used, but probably not with significant operational advantage compared with generally more efficient halogen lamps.

Whatever the source of the light energy, the output

will be spread out from infra-red into the visible. All that can be controlled is frequency where the peak output intensity will exist.

Given present understanding that so-called crystalline melt (breaking chain interlocking?), say for polyethylene, is energetically rather similar to any other melting process, but precedes full melt (breaking to free molecules?), the high specific/latent heat of melting and solidification for the latter gives a good energy margin, even above crystalline melt, without onset of full melt. It appears not to be necessary to go to full melt, only to crystalline melt, sufficiently to remove the first-made geometric memory and thus prevent the pipe from ever creeping back to the previous undersize geometry. The exact speed of towing the device through the re-lining pipe is thus not too critical. Indeed, the machine can always be moved below theoretical maximum speed, but the extra heat energy transferred, above what is required to soften, will never cause melting, even discounting the primary heat self-regulation of the transparency effect, but could remain important to avoid surface melting on the leading edge and/or incident surface of the heated area.

#### Industrial Applicability

Preferred embodiments of this invention afford clean and dry, low cost, 100% no-dig, fast operation with progressive one-stage concurrent heating, forming and cooling; and no possibility of thermoplastic recovery either radial or longitudinal in a low residual stress true

close-fit system not requiring grouting. Preferred transparency onset features give intrinsic temperature regulation. No resins need be used, so storage life is indefinite; and plant requirement is small size and  
5 minimal. No lead-in trenching is needed, nor modifications to existing manholes; and good dimples make lateral connections easy without excavation. Small heated volume/area lead to low losses, and application is seen beyond polyethylene, basically only limited as to thermoplastic  
10 materials meeting requirements hereof, including as to inclusions for controlled heating alternatively to infra-red.

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## CLAIMS

- 1     Method of re-forming a walled thermoplastics member,  
comprising the steps of heating the member to soften  
it sufficiently uniformly through its thickness (but  
5     without full melting) for desired re-forming by fluid  
pressure, and applying pressurised fluid to so re-form  
the member in size and shape as desired.
2.     Method according to claim 1, wherein the member is  
elongate tubular for re-lining a pipeline relative to  
10     which it is cross-sectionally undersize until expanded  
in situ by said re-forming from its interior.
3.     Method according to claim 1 or claim 2, wherein the  
member is of natural polythene.
4.     Apparatus for re-forming a walled thermoplastics  
15     member, comprising means for heating the member to  
soften its thermoplastics material sufficiently  
uniformly through its thickness (but without full  
melting for desired re-forming by fluid pressure, and  
means for applying pressurised fluid to so re-form the  
20     member in size and shape as desired.
5.     Method or apparatus according to any preceding claim,  
wherein the thermoplastics material has inclusions of  
other materials cooperative with application of energy  
for heating to aid even-ness of heating and softening  
25     throughout its wall thickness.
6.     Method or apparatus according to any preceding claim,  
wherein the heating is enough for at least partial  
erasure and replacement of thermoplastic memory as to

geometry before re-forming.

7. Method or apparatus according to any preceding claim, wherein the heating involves application of electromagnetic radiation to which thermoplastics material becomes progressively transparent through its wall thickness in softening without melting.
8. Method or apparatus according to claim 7, wherein the radiation is or includes infra-red.
9. Method or apparatus according to claim 8, wherein the heating is via selective filtering and/or suppressing means for removing frequencies to which the thermoplastics material is undesirably responsive.
10. Apparatus for heating within a tubular member, comprising a machine towable through the member and having an elongate and/or annular array of electric heating elements operative electrically to supply infra-red radiation, and an electrical generator for operating the heating elements.
11. Apparatus according to claim 10, wherein annular said array has associated radially inner reflector means.
12. Apparatus according to claim 10 or claim 11, wherein the machine has a turbine driven by pressurised gas or for desirably pressurising gas and operating the electrical generator
13. Apparatus according to claim 12, wherein elongated and annular said array of heating elements is concentric about said electrical generator with said turbine at one end serving to draw gas over other components for

cooling purposes.

14. Apparatus according to claim 14, comprising tubular transparent means about the array of heating elements.
15. Apparatus according to claim 14 with claim 9, wherein  
5 the transparent means has associated dielectric frequency selective filter means.
16. Apparatus according to claim 13 with claim 9, wherein the heating elements have associated frequency selective suppression means.

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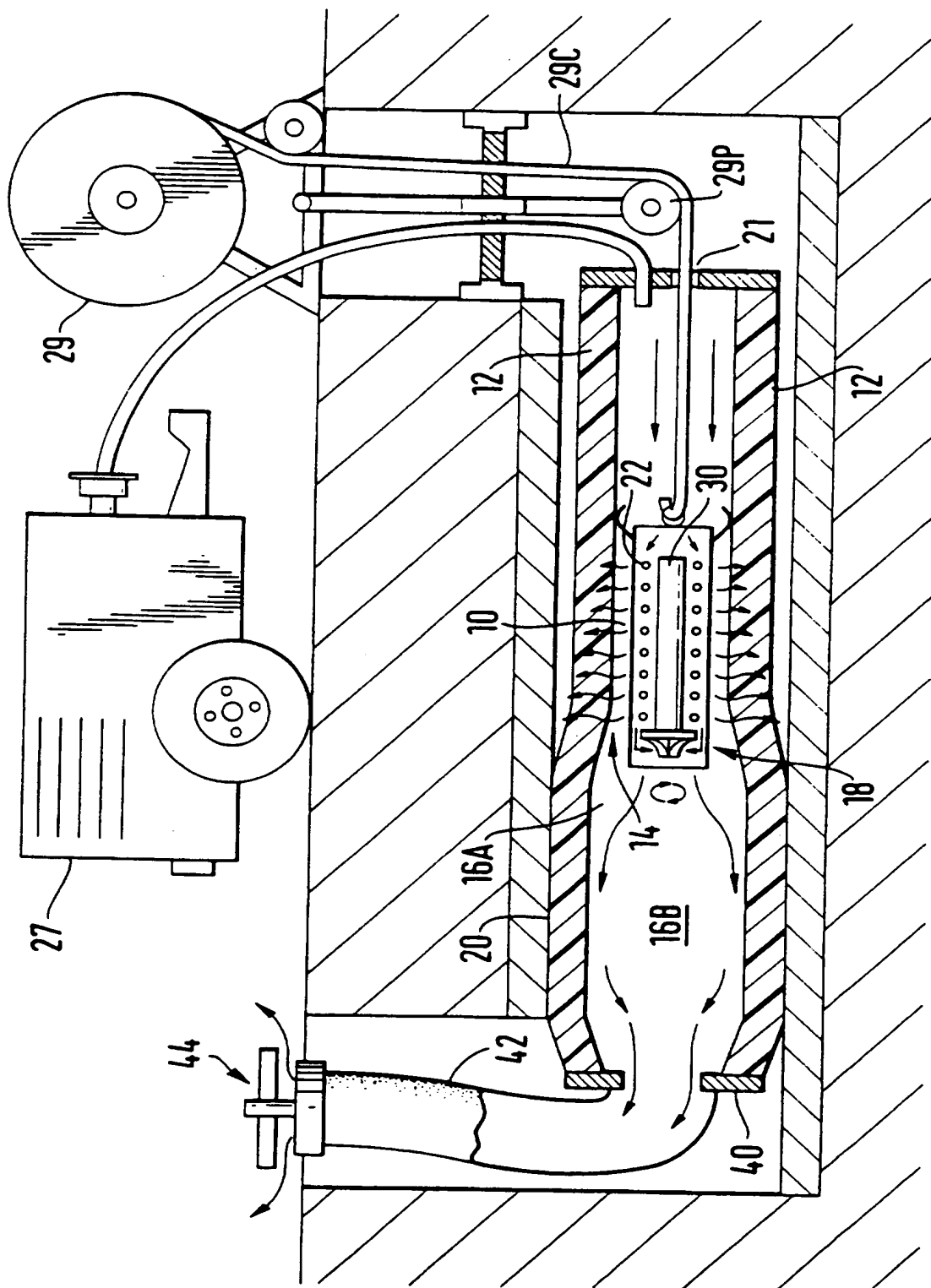


Fig. 1

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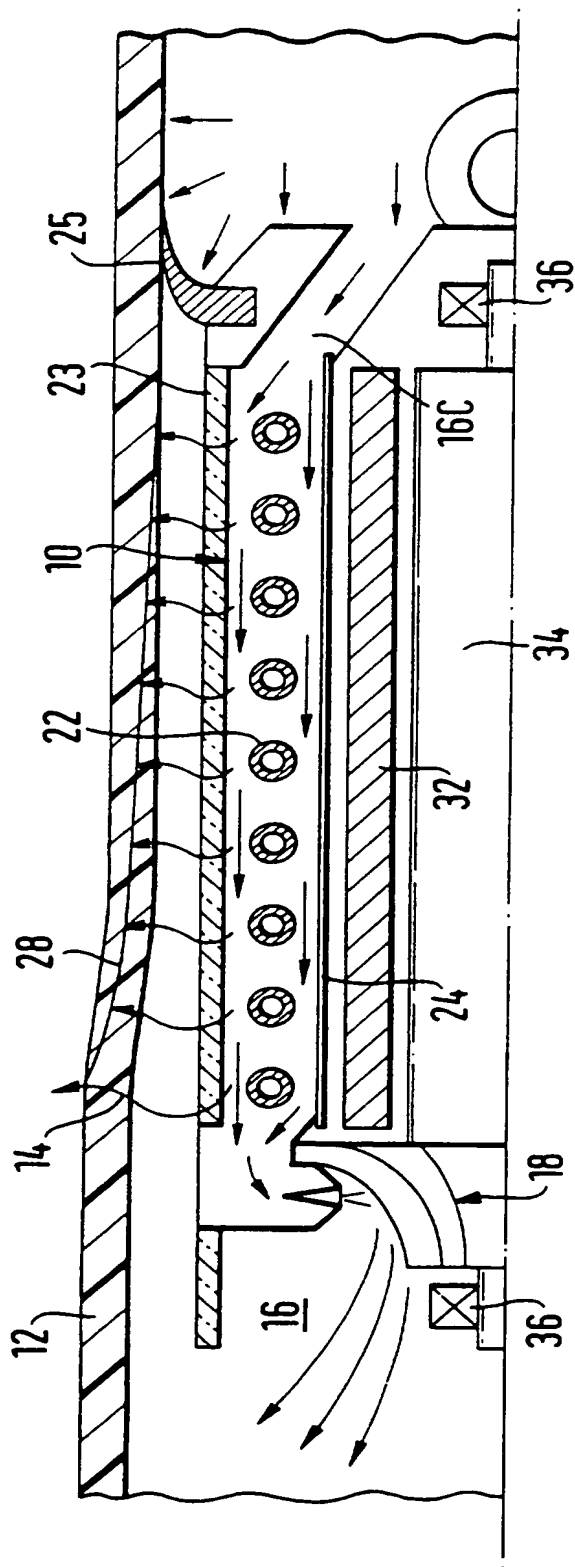


Fig. 2

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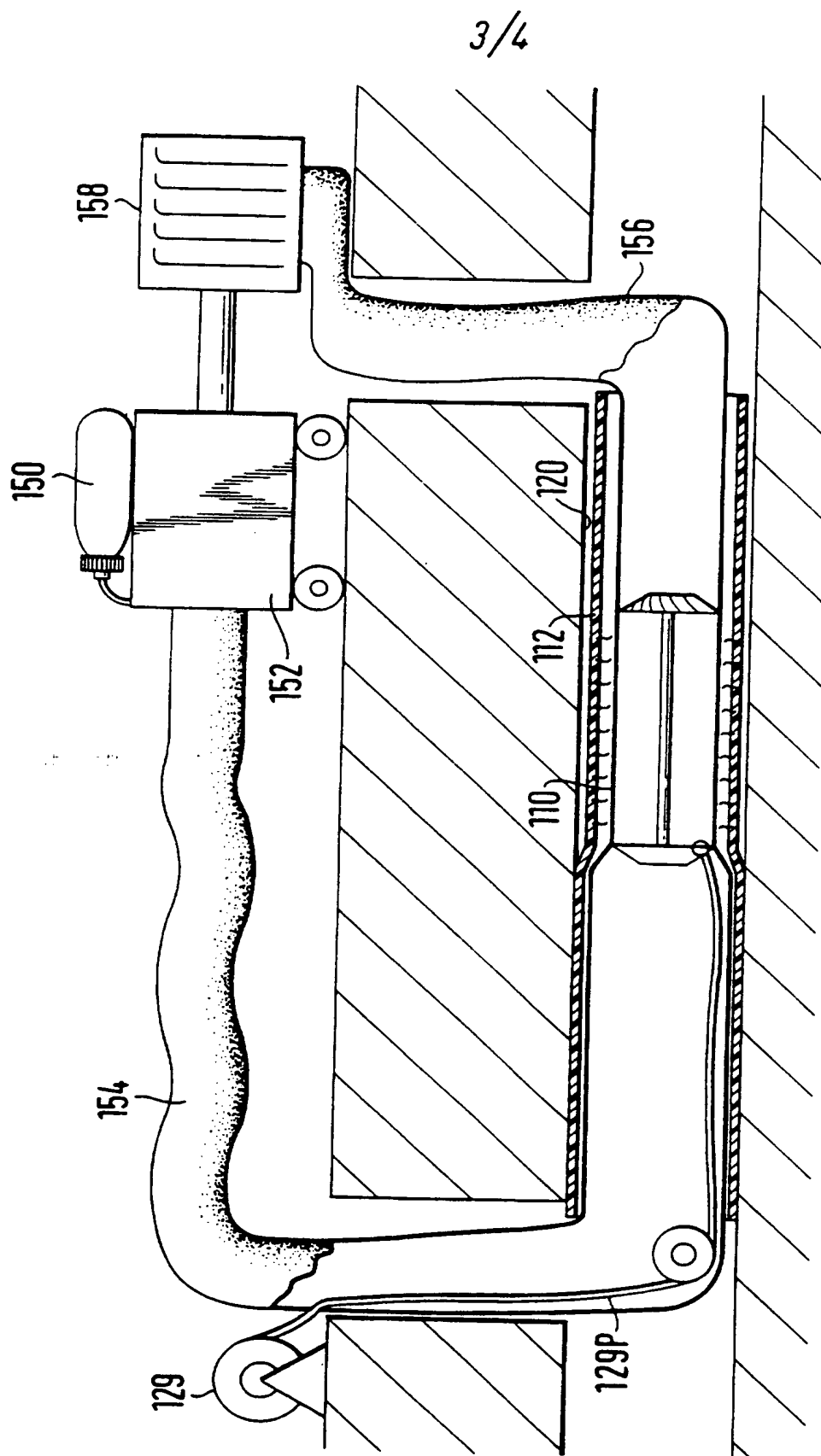


Fig. 3

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Fig. 4

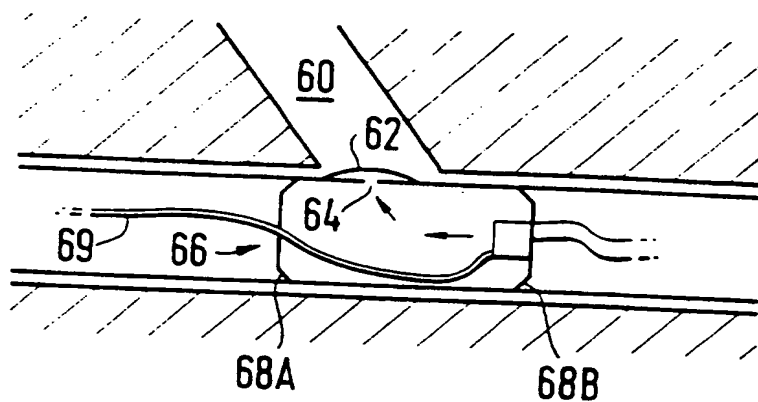


Fig. 5

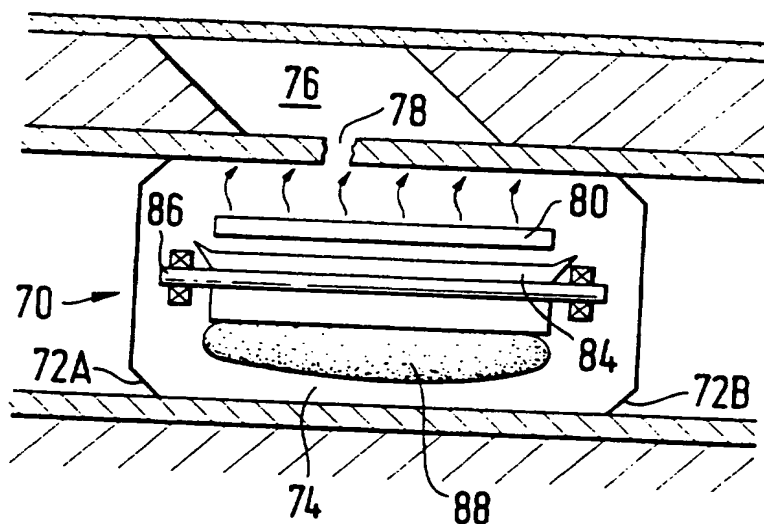
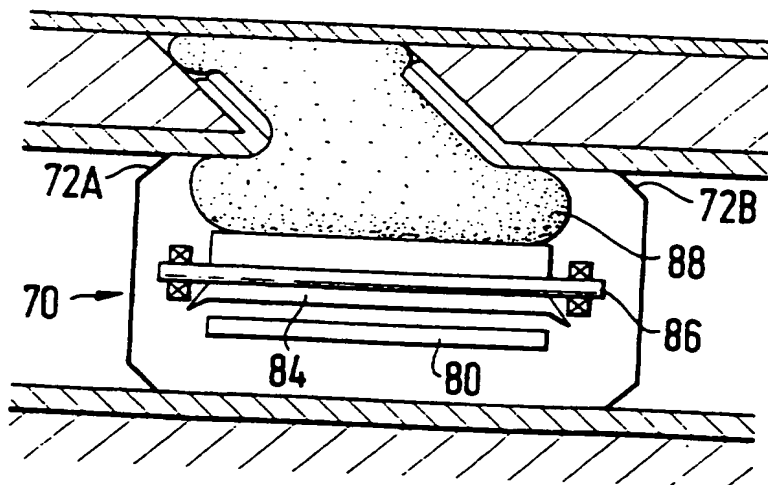


Fig. 6



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# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/GB 95/02954

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B29C63/34 B29C55/24 B29C35/10 F16L55/165 //B29K105:32

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B29C F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE WPI Section Ch, Week 8909 Derwent Publications Ltd., London, GB; Class A32, AN 89-064918 XP002002022 & JP,A,01 016 632 (OSAKA BOSUI CONSTR CO LTD) , 20 January 1989 see abstract	1-4
Y	---	6-8
Y	EP,A,0 369 998 (DU PONT UK) 23 May 1990 see column 2, line 6 - column 3, line 25 see figures	7,8
A	---	10,11
	-/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

3 May 1996

Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

Patent Application No.  
PCT/GB 95/02954

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, Y	<p>           DATABASE WPI            Section Ch, Week 9517            Derwent Publications Ltd., London, GB;            Class A35, AN 95-127839            XP002002023            &amp; JP,A,07 052 247 (FURUKAWA ELECTRIC CO            LTD) , 28 February 1995            see abstract            ---         </p>	6
A	<p>           WO,A,92 16784 (INPIPE SWEDEN AB) 1 October            1992            see page 4, line 28 - line 34            -----         </p>	10

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB 95/02954

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP-A- 62294531	22-12-87
		US-A- 4758302	19-07-88
		US-A- 4781780	01-11-88
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		JP-B- 7041670	10-05-95
		JP-T- 6500512	20-01-94

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